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OF SPEEDED DISCOURSE

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TRAINABILITY OF LISTENING COMPREHENSION OF SPEEDED DISCOURSE¹

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The purpose of the study was to determine whether training with the use of distortion-free, time-compressed speech could increase human capacity to receive spoken language without significant loss of comprehension. Male college students (16 in the experimental, 16 in the control groups) received systematic practice in listening to progressively increased rates of speech from 325 to 475 words per minute. Results indicated that increases up to double normal rate produced no significant loss in comprehension for experimental Ss; statistically significant differences between the performance of the experimental and control groups at higher rates indicated comprehension of rapid speech to be a trainable phenomenon. The data also suggested that listening to speeded speech may have a beneficial effect on reading skill.

Most evidence available suggests that human beings are capable of receiving spoken language faster than speakers can produce it. Evidence is found in studies showing the great capacity of the human auditory mechanism, and in the fact that reading rate often far exceeds speaking (or listening) rates. Nichols (1955) theorized that thought proceeds at 400 or more words per minute (wpm) and that concentration might well be aided by a reconciliation of thought speed and speech speed. Since there is little point in trying to slow thought, consideration has been given to speeding speech without loss of listening comprehension.

Past studies of rapid speech have invariably reported severe attenuation of comprehension with increased rates of presentation. Such studies have used speeded-up tapes or records to increase speech rate, and the re-

sulting frequency shift has produced speech of higher and higher pitch. The resulting loss of comprehension was probably as much due to frequency shift as to the speeding of the speech. The auditory mechanism of the ear itself has apparently *not* been a limitation.

It would clearly be of great advantage to the educational process if the efficiency of listening were improved. While the physical limitations of the speech-producing organs make it impossible to speak at very high rates, certain technical developments have made it possible to process speech in such a way that it is time-compressed (speeded) without being significantly distorted in pitch. This paper is concerned with the investigation of the trainability of the comprehension of speech processed in this way, and the implications of this research for education.

An exhaustive review of many investigations related to these areas has been conducted, but only a few seem to have been important steps leading to the present research. A good deal of related research may be found in the studies of the effects of various types of distortion such as

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peak clipping, masking, frequency filtering, interruption, etc., on the intelligibility of speech sounds. In general the results indicate that English speech is highly resistant to damage. One can do many things to it while retaining some intelligibility because of the degree of redundancy inherent within the language.

Miller and Licklider (1950) studied the articulation (correct reproduction) of spoken, phonetically balanced words (not discourse) under varying conditions of interruption. They found that good intelligibility remained even after considerable loss of the stimulus word. Garvey (1953a, 1953b) then reasoned that it would be possible to physically cut out small segments of the speech record and play the remainder, thus compressing the total speech time, but leaving the original frequencies unaltered. Using discrete, spondaic words, Garvey found it possible to compress speech up to 2.5 times without losing more than 20% intelligibility. He also studied errors and found that his relatively crude "chopping" had damaged only 20 of the 442 speech sounds in the record.

Fairbanks, Everitt, and Jaeger (1954) developed an electronic device for doing essentially what Garvey had done by hand. Fairbanks, Guttman, and Miron (1957b) tried compression techniques on the comprehension of connected discourse. Expositions of technical information were read and compressed at several levels up to 70% with comprehension tested by means of factual tests. At 60% compression (353 wpm) response was about 50% of maximum, but at 50% compression (282 wpm) response was almost 90% of maximum. Although Fairbanks and his colleagues went on to study several other aspects of the situation, such

as adding reinforcing material to the compressed message, and repeating the message, apparently no effort to study the trainability of comprehension under compression has been reported.

More recently, Bixler, Foulke, Amster, and Nolan (1961) began investigations of speech compression as an approach to teaching the blind. They also found that good comprehension remained at essentially twice normal speaking rates and emphasized the potential trainability of comprehension at higher rates.

While the above research has shown that speeded speech is comprehensible in varying degrees, no systematic research has been undertaken to examine the possibility of training comprehension. The main purposes of the research reported here were (a) to demonstrate the trainability of comprehension of speeded speech and (b) to define and explore in a preliminary fashion research problems related to the application of speeded speech in education. Several exploratory experiments and a main experiment were performed. The former will not be described in detail as the main experiment is the subject of this paper.

PROCEDURES

Subjects

Thirty-six male freshmen and sophomores were drawn from four colleges in the Washington, D. C. area and divided into two roughly matched experimental and control groups according to total score on the Nelson-Denny Reading Test and according to their availability. Subjects were screened for gross auditory and visual defects. Subjects were paid \$1.50 per hour plus the opportunity for additional bonuses as rewards for outstanding performance.

Materials

Apparatus consisted of a Tempo-Regulator Model 38 for compression, manufac-

* tured by Telefonbau und Normalzeit, Germany; a Magnecord 728-M tape recorder; a Bogen Ap-250 amplifier; two Electro-Voice EV-2 speakers; a Zenith A-200 Pure-Tone audiometer and ancillary equipment. Experiments were conducted in a sound-deadened laboratory.

Test materials included the following: the Nelson-Denny Reading Test; five tape-recorded passages of sixteenth century English history, 3,500 to 4,000 words long, compressed to speeds of approximately 175 ("normal"), 325, 375, 425, and 475 wpm; five-choice multiple-choice comprehension tests for each of these passages, equated and standardized on a similar population; four full-length novels compressed to speeds of 325, 375, 425, and 475 wpm; and several questionnaires calling for subjective responses.

Design

Although minor variations occurred, the overall design of the experiment was as follows: both experimentals and controls took an initial high-speed (475 wpm) benchmark passage and test and an initial normal-speed benchmark passage and test. In addition all subjects were given one of two alternate forms of the Nelson-Denny Reading Test. The remaining alternate form was administered at the end of the experiment. A biographical data sheet was completed by all subjects, and they were given an audiometric screening test to eliminate any subjects with gross hearing disorders. Then experimentals received practice by spending several hours (spread out over a week) listening to a novel (*Cheaper by the Dozen*) at 325 wpm. At the end of that week, both experimentals and controls received another benchmark passage and test at 325 wpm to assess their progress.

During the next week, experimentals spent several hours listening to another novel (*Miracle New York Yankees*) at a somewhat higher speed, and again experimentals and controls were called back for a benchmark passage and test at the higher speed to measure progress. This procedure was repeated through two additional practice novels (*Man-Eaters of Kumaon*; *Run Silent, Run Deep*) after which a new benchmark passage was presented at 425 wpm to measure generalization of learning, and the initial high-speed passage and test were repeated. The alternate form of the Nelson-Denny Reading Test was administered; a new unstandardized passage was presented at 325 wpm, followed by a test.

Five benchmark passages and tests were prepared; two were employed as the initial high-speed test and the generalization test, the remaining three were used both as low-speed, initial tests and as the progress tests. In order to avoid the interference of order and repetition effects, a partially balanced design was used permitting unbiased comparison between experimentals and controls at each stage of the experiment with respect to mean score and increment in mean score on the benchmark tests. A completely balanced design would have required more subjects and passages than would have been practicable.

In addition to the comparisons implied above, the design permitted a before-after comparison of experimentals and controls with respect to the Nelson-Denny Reading Test scores.

Questionnaires were given to experimental subjects during and after the experiment as a debriefing. These were intended to gather subjective reactions to the procedures and to speeded speech. Following each of the three practice sessions on the last novel, brief essay tests covering the material presented were administered as a stimulus to attention.

RESULTS

The major results of this experiment concern the listening comprehension test-score means for experimentals as compared to controls, as a function of speed; and the mean experimental performance as compared to controls on the high-speed base-line passage which was administered at the beginning of the experiment and repeated at the end. Additional results of interest are the relationships of performance on the listening comprehension tests with performance on the Nelson-Denny Reading Test, and also the possible effects of the practice in rapid listening on the several Nelson-Denny test scores.

Listening Comprehension

The listening-comprehension test results are summarized in Tables 1 and 2. Two control and two experimental subjects failed to complete the experiment. Thus all results re-

TABLE 1

MEANS AND STANDARD DEVIATIONS ON PRORATED LISTENING SCORES FOR
EXPERIMENTALS AND CONTROLS BY SPEED AND FOR SPEED COMPARISONS

Time of test	Test ^a (in wpm)	Experimental		Control	
		M	SD	M	SD
Initial test	175	15.7	4.64	17.4	3.43
Initial test	475	4.2	2.03	6.2	3.88
After 1st week practice at 325 wpm	325	14.0	6.76	13.9	3.96
After 2nd week practice at 375 wpm	375(1)	13.6	5.08	12.9	5.38
After 3rd week practice at 425 wpm	375(2)	13.6	4.53	13.1	4.13
After 4th week practice at 425/475 wpm	425	12.2	4.33	8.6	3.55
Posttest	475	8.8	2.64	6.8	3.58
Posttest	325	17.2	5.68	16.0	3.61

Note.—*N* = 16 for each group, experimental and control.

^a In order of presentation.

ported are based on 16 subjects in each group. The scores were prorated so that all tests were equivalent in length, and scores were corrected for guessing.

An examination of the results suggested two major conclusions. First, although controls may have been a slightly more able group, experimentals overtook them after the first week's practice and maintained or increased that advantage thenceforth; second, there was ample evidence of wide individual differences within both groups at all levels.

Although there appeared to be a tendency for controls to be superior initially, there was no significant difference between experimentals and controls at either the 175-wpm level or at the initial 475-wpm level. No significant difference existed between experimental and control groups at 325 wpm or 375 wpm. However, a sharply significant difference appeared at 425 wpm which was the new passage introduced as a measure of experimental generalization of practice effects to new material. This result indicated clearly that the generalization did take place. Further, there was also a significant difference between the two groups on the repeated high-speed base-line passage (475 wpm).

Thus, under the impact of practice, the experimental group was able to build a greater skill in listening comprehension at higher levels of speed than the control group was able to develop.

Another way to look at these results is in terms of the mean decrement from listening-comprehension performance at normal speed for experimentals versus controls. Instead of a straight comparison of test scores, this procedure compares the two groups in terms of changes from their respective base-line performances.

TABLE 2

SIGNIFICANCE OF DIFFERENCES BETWEEN
MEANS PRESENTED IN TABLE 1^a ON
PRORATED LISTENING SCORES FOR
EXPERIMENTALS AND CON-
TROLS BY SPEED
COMPARISONS

Comparison between tests (wpm)	Mean differences		Significance of differences Experimental vs. control
	Exp.	Control	
175-325	-1.7	-3.5**	
175-325 (p. exp.)	1.5	-1.4	
175-375 (1)	-2.1	-4.4**	.05 < <i>p</i> < .06
175-375 (2)	-2.0	-4.4**	<i>p</i> < .05
175-425	-3.5*	-8.8**	<i>p</i> < .01
325-325 (p. exp.)	3.1*	2.0	
475-475 (repeated)	4.6*	0.6	<i>p</i> < .01

Note.—*N* = 16.

^a Figures may not agree precisely due to rounding error.

* *p* < .05.

** *p* < .01.

TABLE 3
MEAN PERFORMANCE BY SPEED AS A PER-
CENTAGE OF MEAN PERFORMANCE AT
NORMAL SPEED

Test ^a (wpm)	Experimental (base = 15.7)	Control (base = 17.4)
175	100.0	100.0
475 (initial)	26.8	35.6
325	89.2	79.9
375 (1)	86.6	74.1
375 (2)	86.6	75.3
425	77.7	49.4
475 (repeated)	56.1	39.1
325 (post-exp.)	109.6	92.0

^a In order of presentation.

These results can be summarized briefly. At 325 wpm the experimental mean decrement was smaller but not significantly different from the control mean decrement. At 375 (a) the difference approached significance (about 6% level, one-tailed). At 375 (b) the experimental decrement was significantly smaller than that of the control group. And for 425 and 475 (repeated) the difference was significant beyond the .001 level in the expected direction.

It is of some interest to examine the extent of the decrement observed at each speed. One way to do this is to express the mean score at each speed as a percentage of the mean score at normal speed. Table 3 shows these results, based on scores corrected for guessing. It may be seen that even at 425 wpm the experimentals had better than 75% comprehension, undoubtedly because of the practice periods. Controls did not quite achieve the 50% level, although their initial high-speed base performance tended to be higher. Experimentals also did distinctly better on the repeated high-speed base-line passage, managing to maintain well over 50% comprehension at this level.

Another point to be made is that *even without practice*, control per-

formance declined only about 20% at more than double normal speaking rates. This result is similar to the findings of Fairbanks et al. (1957b)—90% comprehension at 282 wpm—and Bixler et al. (1961). It is also supported by the pretest results for the present study which actually found improved comprehension at 325 wpm. Thus, even without practice, it appears that normal rates of spoken material could be essentially doubled with little or no loss in comprehension.

The results on a new (but not equated) postexperimental passage at 325 wpm suggested that high-speed practice may also be beneficial in improving normal comprehension levels. This finding was at best tentative. Further experimentation to test the effects of listening practice on comprehension of speeded speech is now underway.

Finally, another very tentative result might be mentioned. The procedures produced a significant increment in reading rate for both experimental and control groups. There was a hint of relationship between reading and listening speeds since the sharpest declines in listening comprehension tended to occur at about the final mean reading rates of both groups. This finding was also true in the pretest study results. Again, further investigation is underway.

Reading Test Results

Alternate forms of the Nelson-Denny Reading Test were administered before and after the experiment. About half of the experimentals and half of the controls took Form A first; the others, Form B.

Both experimental and control groups showed a significant mean improvement in reading rate (see Table 4). Experimentals advanced from 339 wpm to 390 wpm; controls

TABLE 4

MEANS, STANDARD DEVIATIONS, AND EXPERIMENTAL-CONTROL DIFFERENCES ON NELSON-DENNY SCORES AND LAST ITEM ATTEMPTED ON TESTS ADMINISTERED BEFORE AND AFTER TRAINING

Nelson-Denny score	Experimentals				Controls				Significance of mean differences		
	1st admin.		2nd admin.		1st admin.		2nd admin.		1st vs. 2nd adm.		Comparison of mean differences exp. vs. cont.
	M	SD	M	SD	M	SD	M	SD	Exp.	Cont.	
Vocabulary ^a	60.6	16.40	65.1	13.11	54.2	12.86	59.4	13.79	$p < .05$	$p < .05$	$p < .05$
Comprehension ^a	51.8	13.03	56.3	8.85	55.9	9.00	54.7	8.71	$p < .05$	$p < .05$	
Total score ^a	112.3	25.50	121.3	19.53	110.2	18.55	114.2	20.13	$p < .05$	$p < .05$	
Reading rate	339.0	116.77	390.0	107.94	351.0	123.49	411.0	110.65	$p < .05$	$p < .05$	
Last-item-attempted (vocabulary)	76.3	15.84	85.3	12.72	75.9	14.77	84.0	14.23	$p < .01$	$p < .05$	
Last-item-attempted (comprehension)	33.5	3.81	35.2	1.42	35.1	1.87	35.6	1.02	$p < .05$		

^a Corrected for guessing.

from 351 wpm to 411 wpm. (There was no significant difference between the groups.) Both groups also improved significantly, but not differentially, in mean vocabulary score. This may have been a result of higher reading rates, since the mean last item attempted on the vocabulary test increased significantly for both groups.

The comprehension test, however, showed a significant rise both in score and in last item attempted for experimentals, but no significant change in either for controls. The mean increment on the comprehension score was significantly larger for experimentals than for controls. The total score, based on both vocabulary and comprehension tests, showed a significant rise for experimentals, with no significant change for controls. The differential change between the groups was not significant.

The results suggested that the emphasis on speed which was a general characteristic of the experiment, carried over to the Nelson-Denny scores both for controls and experimentals. This was illustrated by the significant increases observed for vocabulary scores, reading rates, and last-item-attempted scores when the

postexperimental administration was compared to the preexperimental administration. The significant increase in comprehension score for experimentals, but not for controls, is probably not explained in terms of increases in last-item-attempted scores (which, though significant, were very small). A more likely explanation is increased facility (as a result of practice) in comprehension skills.

Nelson-Denny scores for first and second administrations were correlated in order to estimate the consistency with which subjects scored. These correlations, in general, approached the alternate-form reliabilities reported in the manual for the test and are shown below.

	Vocabulary	Comprehension	Total score	Reading rate
Experimental group	.88	.71	.93	.85
Control group	.89	.47	.83	.77

The rather low correlation for controls on comprehension may reflect a different approach to the second administration of the test on the part of some subjects. The emphasis on speed without the benefit of the improved skills acquired by the experimentals may have caused some subjects to read too hastily and

lose comprehension, while influencing others to cover more material than they would normally, thus improving their comprehension scores. Such a dual effect might also explain the failure of the controls to show a mean improvement as pointed out above. On the other hand, the first administration scores for this group might simply have been fortuitously high.

Other Findings

A number of other, more limited analyses were carried out, and the findings are mentioned briefly here.

Effects of Repetition. It has been noted that passages were repeated for some members of each group at each speed. The evidence suggested that repetition is beneficial. Again, this is similar to the finding of Fairbanks, Guttman, and Miron (1957a) that repetition of a compressed passage is of some benefit. In every instance where a comparison could be made between the subjects repeating passages and those not repeating at the same speed, the difference in mean increment favored the repeater. The experimental repeats also seemed to fare better than the control repeats. However, the design was not strictly adequate to study the effects of repetition, and these data are only suggestive.

Correlations. A number of the variables in the study were intercorrelated for experimentals and controls (see Table 5). These correlations showed for experimental subjects that doing well on the measure of generalized practice effect (425-wpm test) was significantly related to performance on the initial base-line passage at 175 wpm and to performance after 1 week of practice (the 325 score); and moderately to initial Nelson-Denny total score. Control performance at the 425-wpm point was significantly related to these same three

variables and also to the repetition of the high-speed base-line passage at 475 wpm.

The Fisher transformation was used to test the differences between the correlation for experimentals and those for controls. Because of the small sizes of the groups, some apparent differences do not reach significance. However, correlations between 175 and 325, Nelson-Denny total and 325, and 325 and 425 were significantly higher for experimentals than for controls, at least at the 5%, one-tailed level. These differences suggest that the training received by the experimentals had a large interaction with their normal listening ability. In other words, ability *plus* training accounted for performance at 325. Low correlations between 175 and 475 (initial) for both groups tend to support this interpretation. The very high relationship between 325 and 425 for the experimentals probably reflects the rapidity and consistency of training effects. The comparatively high relationship between 425 and 475 (repeated) for the controls may reflect a rather consistent, but somewhat unsuccessful, (means were low, see Table 1) approach to handling the high-speed material arising from only limited exposure to high-speed material.

Performance on the repetition of the high-speed base-line passage (475 repeated) was significantly related to initial Nelson-Denny total score for both experimental and control groups. Since experimentals and controls are not significantly different from each other in this relationship, one possible interpretation might be that those of higher verbal abilities may profit more from the repetition of the 475 passage.

Questionnaires. At the end of the fourth and last week of the experiment proper, all subjects were given a debriefing questionnaire to complete.

TABLE 5

SELECTED INTERCORRELATIONS OF READING AND LISTENING PERFORMANCE FOR
EXPERIMENTAL AND CONTROL SUBJECTS

	175	325	425	475 (i)	475 (r)	Nelson-Denny (preexperimental)	
						Total	R. rate
175	—	.79 .03	.69 .45	.37 .36	.40 .32	.79 .36	.28 .02
325		—	.84 .49	.15 .12	.41 .38	.66 .12	.17 — .15
425			—	.21 .41	.35 .70	.50 .49	.06 .12
475 (initial)				—	.79 .41	.31 .52	.33 .22
475 (repeated)					—	.55 .52	.47 — .11
Total score (N-D)						—	.44 .28

Note.—Experimental-group ($N = 16$) correlations are given as the first entry in each cell; Control-group ($N = 16$) values as the second entry. Correlations $\geq .43$ are significantly greater than zero at the 5%, one-tailed level.

The purpose of this procedure was to give the subjects an opportunity to express their subjective reactions to the experiments. In describing the "most significant aspect of the experiment" about 70% of each group named improvement in their listening ability at high speeds. Subjects were given a list of potential listening aids including the following: an outline of the text, the use of earphones, a copy of the text to be read simultaneously, a list of key words, frequent rests, etc., and asked to judge those three which would be the most helpful. Both groups overwhelmingly felt that an outline of the text presented beforehand would be the most useful tool in aiding their comprehension of subsequent rapid speech. When asked to name their most frequent listening problem, most subjects indicated that the maintenance of attention was the chief problem. In describing what they were best able to hear while

listening to rapid speech, subjects cited familiar words, proper nouns, and various features of prosody such as stress, pitch, and juncture. There was a tendency to judge long words to be more intelligible than short words. The general consensus was that compressed speech might be a useful technique especially with non-technical educational material.

DISCUSSION

The findings of the present study would appear to have potentially significant implications for education. A large proportion of high-school and college pedagogy is carried on by the lecture method. To date lecturers have been limited in the amount of material which could be presented in a classroom session by their normal speaking rates for presenting such material. The present findings suggest that where 80% or better of normal speed comprehension is acceptable,

even naive listeners can tolerate close to twice normal presentation speeds. Further, the results show that with 8-10 hours of training substantially higher speeds are possible.

At a time when the school curriculum is becoming more and more crowded, the possibility of presenting a given amount of information in substantially less time than is now required is certainly of potential significance. Time freed in such a fashion might be used in increasing the number of students taught by an individual instructor; in increasing the amount of material presented; or in engaging in any one of a number of educational activities such as structured discussions, review, self-study, demonstrations, or other innovative activities.

It is not suggested that the presently described technique is appropriate for all kinds of material or for all educational situations. It remains for further research, some of which is now being undertaken by the present authors, to describe more completely the precise conditions under which compressed speech may be applied to education. The present research has given rise to a number of hypotheses of obvious implications for education. For example, it can be hypothesized that review of previously presented material could be more efficiently accomplished by means of compressed speech; the entire lecture, complete with instructor's intonations and emphases might be re-presented at high speed as a review. It could be hypothesized that compressed speech training might significantly improve comprehension of normal speed presentations. It might be hypothesized that long-term re-

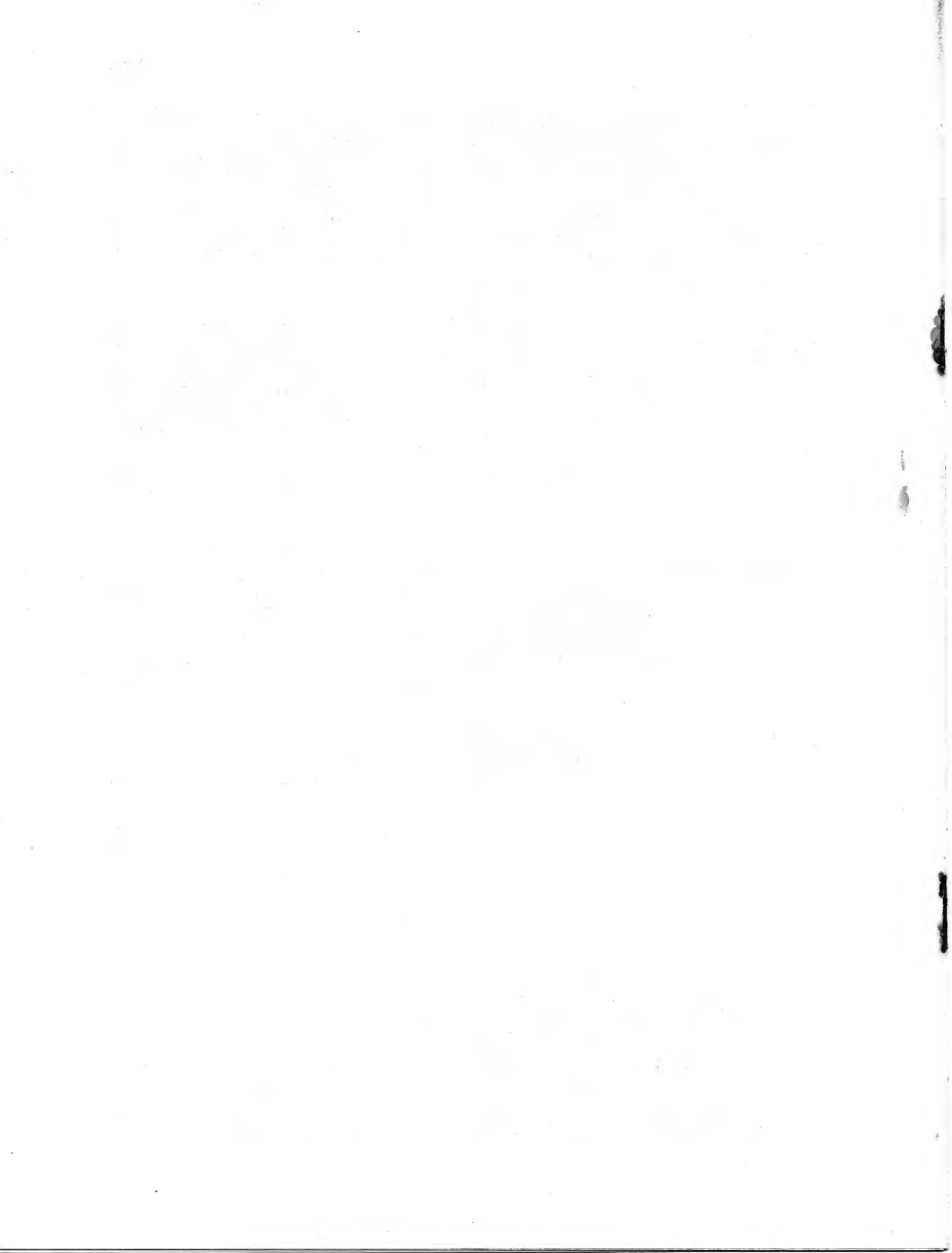
tention might be enhanced because of the close attention required in listening to a compressed presentation. These and many other hypotheses are now under investigation, and it is the results of such research which will ultimately define the educational implications of the compressed speech technique.

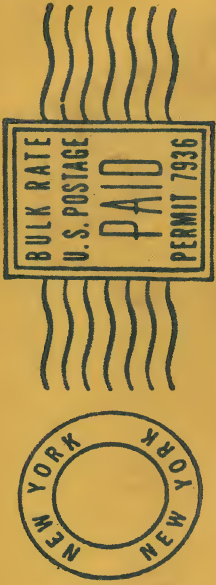
Finally, it is hoped that attention to the above research problems, and to the interrelationships between listening and reading suggested by the present study might well draw increased attention on the part of the research community to the important but relatively neglected area of listening comprehension.

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